REAL OPTION VALUE

CHAPTER 1 INTRODUCTION TO REAL OPTIONS

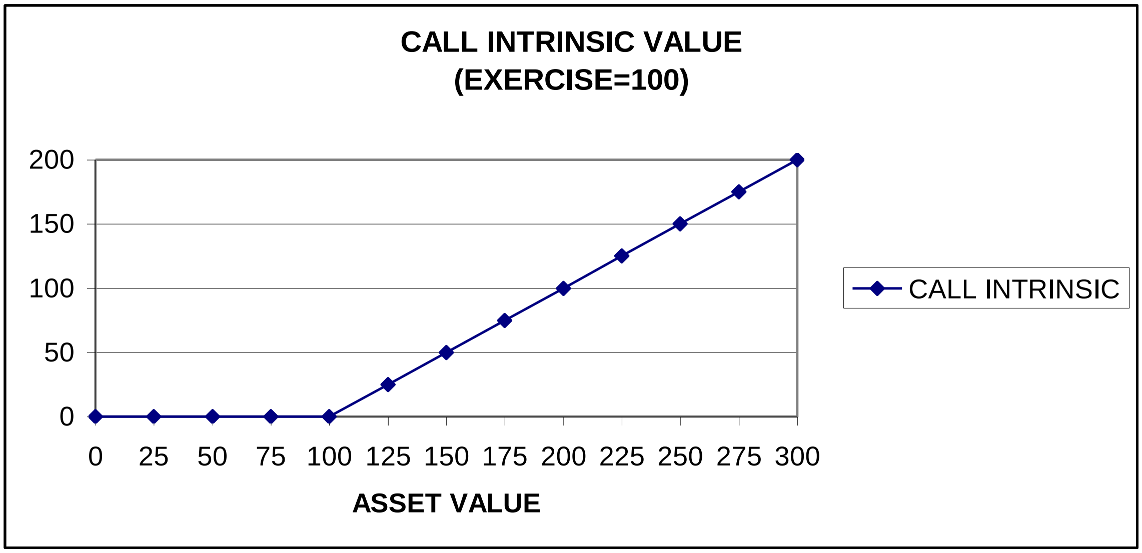
"Real options" are opportunities (and possibly implicit commitments) to acquire or develop or dispose of real assets at an investment and implementation cost determined (or estimated) in the present with the benefits delivered in the future. Like financial options, there is conceptually an underlying asset, or liability, that determines the option value at termination. However, unlike financial options, real options are not (yet) commonly traded, are often difficult to identify, with possibly few comparables and limited public information, and may involve complex methods for valuation. Many real projects are not proprietary (until perhaps patented), so competition and first mover advantages/disadvantages must be considered. Some of the differences between financial and real options have diminished as real asset “tracking stocks” and “synthetic real options” are traded, sometimes linked to specific identifiable indices and valued using common option pricing methodology.

1.1 REAL OPTION DEFINITIONS

Real **call** options are opportunities for the holder to benefit from the upside, while only suffering the loss of **premium** (initially paid for the option, equals pre-investment costs) as a downside. **Put** options are opportunities for the holder to benefit from the downside, such as switching to alternatives as input costs change. Written real put options may involve real or implicit warranties of the value of projects, as well as required future expenditures such as further clinical trials, or liabilities from harmful products.

Real option analysis is an appropriate valuation technique for a firm's **growth** opportunities, (call options) including **timing** (exercising options) for future investments. Indeed almost every project competes with itself postponed, in view of the uncertainty in interest rates. Projects that can be **abandoned** for scrap value have embedded put options.

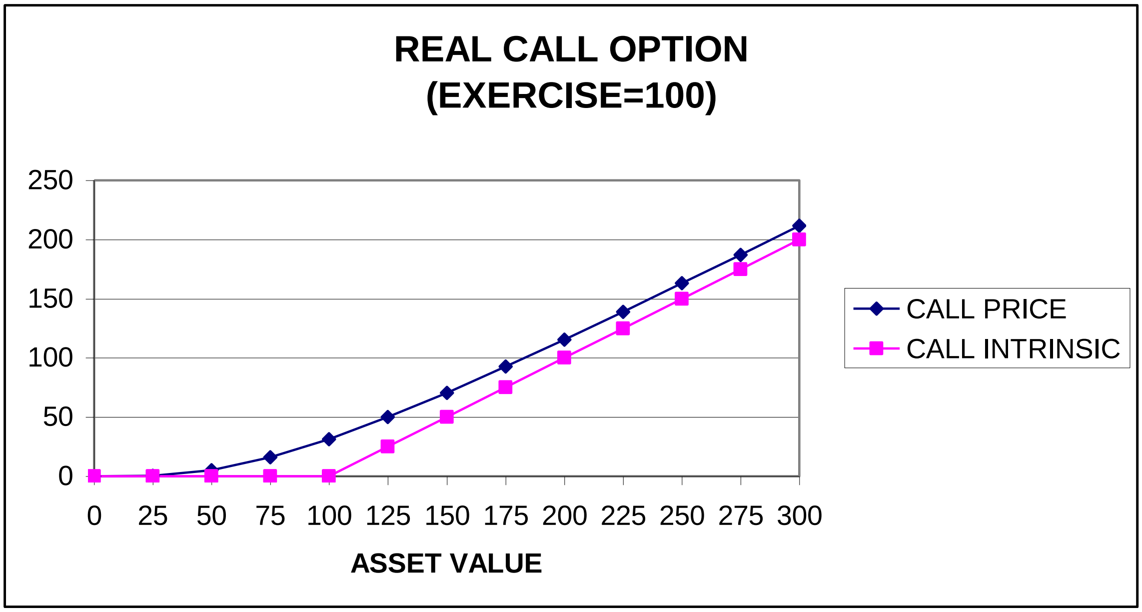
Figure 1.1



The **payoff** of a real call option is illustrated in Figure 1.1, where the ultimate value of the underlying asset (V), say the value of a patented new drug, is on the horizontal axis, and the realized value of a call option on that asset, with an **exercise price** (payment at the time the option is exercised, development investment cost (K) for a real drug option) of $100, is on the vertical axis. At an exercise price of $100, when the value of the asset is $100, the payoff is nil, but when the value of the asset is $300, the payoff is $200. The payoff is also known as the **intrinsic** call option value that is the value of the option if it is exercised immediately. In Figure 1.1, to the left of $100, the asset value is below the exercise price, so the option is **out-of-the-money**; if this holds at the option **expiration** date (time when the option expires), the option is worthless. To the right of $100, the asset value exceeds the exercise price, so the option is **in-the-money**. **At-the-money** is when the asset value equals $100.

However, prior to expiration, the option is worth more than the intrinsic value. Figure 2 shows the value of a two year **European** (cannot be exercised until expiration) call option (using the Black-Scholes (1973) model, covered in Chapter 2). This assumes that the **volatility** of the underlying asset over the two years is expected to be 50%, the asset income is nil, and the **riskfree interest rate** is 5%.

Figure 1.2



Volatility is the fluctuation of the asset value over a period of time, usually expressed as a standard deviation per annum. Note that the call option value is always greater than or equal to the intrinsic value, but the difference between the option value and the intrinsic value declines as the option becomes more in-the-money.

1.2 WHY REAL OPTIONS?

What is so important about real options? Compared with traditional business appraisal methods such as net present value, using real options often leads to different business decisions and different values. Usually real options require the identification of an "underlying asset value", that is the value of a new office building or new ship, new product or new technology when completed. Sometimes that underlying asset value can be established through "comparables" (current market price of similar buildings or ships); and sometimes current commodity futures prices can be used as expectational parameters for future values, such as future petroleum production. However, often future cash flows must be forecast, and discounted at risk-adjusted rates, to obtain the current present value of the prospective underlying asset value. But the use of that underlying asset value in determining project structure and timing will typically be very different using real option methodology, compared to traditional methods.

How are real options different from financial options? Usually the underlying asset for financial options is exogenous or experiential, that is management cannot influence the price or quantity of the asset over the life of the option. For real options, the underlying asset is real, and may be endogenous, that is affected by management decisions regarding style, structure and even price. Of course, real option values are not unrelated to capital markets, or commodity and futures markets, since ultimately the value of a real option in the long term is what buyers are willing to pay and sellers willing to accept, compared to alternatives.

What types of business decisions should be based on real option methodology?

- Stages of expansion or contraction, especially where the management actions are not altogether obvious (that is the growth investment decision is not way-in-the-money, "slam dunk" decisions that are easily based on traditional investment criteria).
- Refurbishing an office for a particular tenant might be viewed as a real option, if the refurbishing costs are very specialized and thus sunk.
- Real options might prove useful considering the option value of an exit from an on-going business, where traditional methods are limited to deterministic exit scenarios. Abandonment or switching use may be actions where the results are irreversible (scrapping a ship makes it difficult to reconstruct the ship).
- Where there is flexibility on the timing and amount of investments (not last chance opportunities), real options are relevant, such as in R&D and buying/selling technology.
- Competitive real option models are highly relevant where there are competitive advantages for leaders (first to innovate) and also advantages for followers, waiting to learn by leaders' mistakes.

Real option valuation ("ROV") often leads to simply different decisions than reached using traditional methods like Net Present Value. Typically, ROV leads to deferred timing of investments (hysteresis, or inertia, that is deferred entry or exit as input and output prices change). Alternatively, in a competitive environment, sometimes ROV leads to deliberate earlier timing of investments if there is the possibility of a competitive advantage from pre-emption. Above all, ROV emphasizes flexibility in project structure and management, considering alternatives (outsourcing, scale, modularity), with an emphasis on the upside, while guarding against the downside through caution, and flexibility in projects. The volatility of future cash flows or values, sometimes including both up and down jumps, is a required input for ROV. The basic paradigm is: don't necessarily invest, even if the net present value is positive, if there is the possibility of negative present values in the future (due perhaps to increases in volatility). Keep your options open. However, in a competitive environment, watch the competition, and judge whether there are competitive advantages in being a first mover that might offset the usual advantages of keeping your options open. Don't necessarily abandon facilities even if the current net present value is negative, if there are costs of suspension or abandonment, and option values of reactivating production. Consider planning and R&D expenses as equivalent to paying a call option premium, if payment enables future investments and comparative advantages. Stop R&D if the expense exceeds the value of the real option, if for instance, the real option is out-of-the-money and the future outcome is not volatile.

The "drivers" of real option values are the payoff structure, the current value and expected future volatility of the underlying asset, the current investment cost and volatility, any ongoing income from current use, and projected income from projected changes. Ask if the projected business structure is like a call or put option, or a spread between value and cost, or a sequence of investment decisions. Consider the present value of the cost of investing, expanding, contracting, switching use or eventual abandonment. Always consider the future cash flows, or comparable values of the underlying asset and investment cost, the allowable or feasible time to make the investment, and the future volatility of value and cost.

Real options may involve complex mathematics, after the initial considerations and basic modeling. Typically the closer to reality, the more complex the model and hence the more advanced the mathematics. Managers are not expected to be mathematicians, but rather common sense decision makers, who frame the various aspects of a real options context, view the basic payoffs and drivers, and who then can arrive at a judgment on whether mathematical refinement is required (and the benefit exceeds the cost). A sensible approach to the mathematics required is in ascending order of difficulty. Easiest and transparent are simple binomials. European finite maturity vanilla (Black-Scholes) options are commonly used by non-mathematicians based on Excel or similar basic software. American perpetuities (like managing tree plantations, farming, and some property) involve relatively easy maths, and usually provide the outside limit of real option values. European finite spread options and some exotic American perpetual options (like spreads or exchanges) do not require complex maths. Real sequential and competitive options are sometimes harder, but the Excel Tools/Solver often provides convenient easy solutions. Harder are real life options such as careers, company and strategy problems, where imagination and business intuition are required.

1.3 PRACTICAL USES OF REAL OPTIONS

What are the practical uses of real options? Real options are used in the early planning stages of basic research, theoretical and experimental phases. Either in the context of continuous testing, or sequential "clinical" type trials, the information obtained is critical for option evaluation. Investment options are essential models for deciding the timing and type of new product developments, including marketing and production. Operating options include the deferral of product upgrades, downsizing or expanding new product developments, and switching current innovations to related alternatives. Exiting projects through sales of the business or joint ventures is like an abandonment option. Risk sharing may involve "protection" on the downside through (non-repayable) external sources, or joint ventures where there are payments according to milestones, which eventually involve sharing the upside. Market-based funding options cover the choices between debt and equity funding of projects, including the many varieties in between, as well as tracking stocks, and/or partnership ventures. Industry strategy real options view patterns of the timing of innovation and new developments, in the context of competition and product cycles. Regulation and taxation (and subsidy) of investments involve macro economic and political considerations, sometimes using the models from planning, investment timing and industry strategy.

1. General Planning: Given uncertainty, there may be a value in deferring investments, or delaying the exploitation of proprietary investments.
2. Planning: Partly irrecoverable expenditures in stages are viewed as sequential options, or compound options on commercial developments.
3. Information: With experimental and clinical project testing and market research, information is valuable for both real option and development values.
4. Investment: Timing of new projects and product developments, if future development values are uncertain.
5. Operating: Covers on-going active real option management, where there is flexibility in the research and product/customer mix over time, and in the intensity of the project.
6. Abandonment: What is the value of a project where there is an alternative use, or salvage value, even if the original project targets are missed?
7. Risk Sharing: What is the fair-deal between researchers and capitalists, for risk sharing arrangements, given forecast development volatility?
8. Funding: Includes real option capital market links and issuing/repurchasing equity, debt and quasi-equity.
9. Industry Strategy: What are the pros/cons of being the leader in projects rather than the follower, justifying the timing of investments in a competitive environment?
10. Regulation: When there are externalities (general benefit from cooperation effects and networks), what is the economic and political optimal taxation/subsidy of such expenditures?

Future Developments: There are many challenges in real options, including model refinements, empirical problems, and developing/testing new tools for practical real option management.

The generic real options in this book are presented in order of the complexity of the types of assumptions required: first is the simple binomial assumption that the asset price moves only up or down; then that the real option is European, with a constant investment cost, which can be exercised only at a determined maturity; then an American perpetual option, which can be exercised at any time, but the investment cost is constant; then an American perpetual option where the investment cost is variable; then an American option which can be exercised any time until a determined maturity; and finally more realistic real options concerning sequential investments, project scale, and competitive environments.

The American perpetuities are relatively easy to solve. Usually there is a closed-form solution of a differential equation, which provides optimal timing and valuation of various types of investments. Proprietary scale options consider multiple strategies, invest, expand, contract, abandon. If these are perpetuities, the solution is a simultaneous solution of systems of equations. These provide optimal timing for multiple decisions, mergers and divestures.

Competitive games consider a Leader-Follower environment, where there is a comparative advantage of cost, innovation or scale, or first mover advantage in obtaining dominant market share and temporary monopoly profits. There are closed-form solutions for multi-factor models. These models are often realistic for practical use in many investment decisions and security analysis.